AD-A044 649 AEROSPACE CORP EL SEGUNDO CALIF SPACE SCIENCES LAB F/G 17/8
SOURCE LOCATING PROCEDURE.(U)
JUL 77 D C PRIDMORE-BROWN, L M FRIESEN F04701-76-C-0077
UNCLASSIFIED TR-0077(2632)-1 SAMSO-TR-77-137 NL

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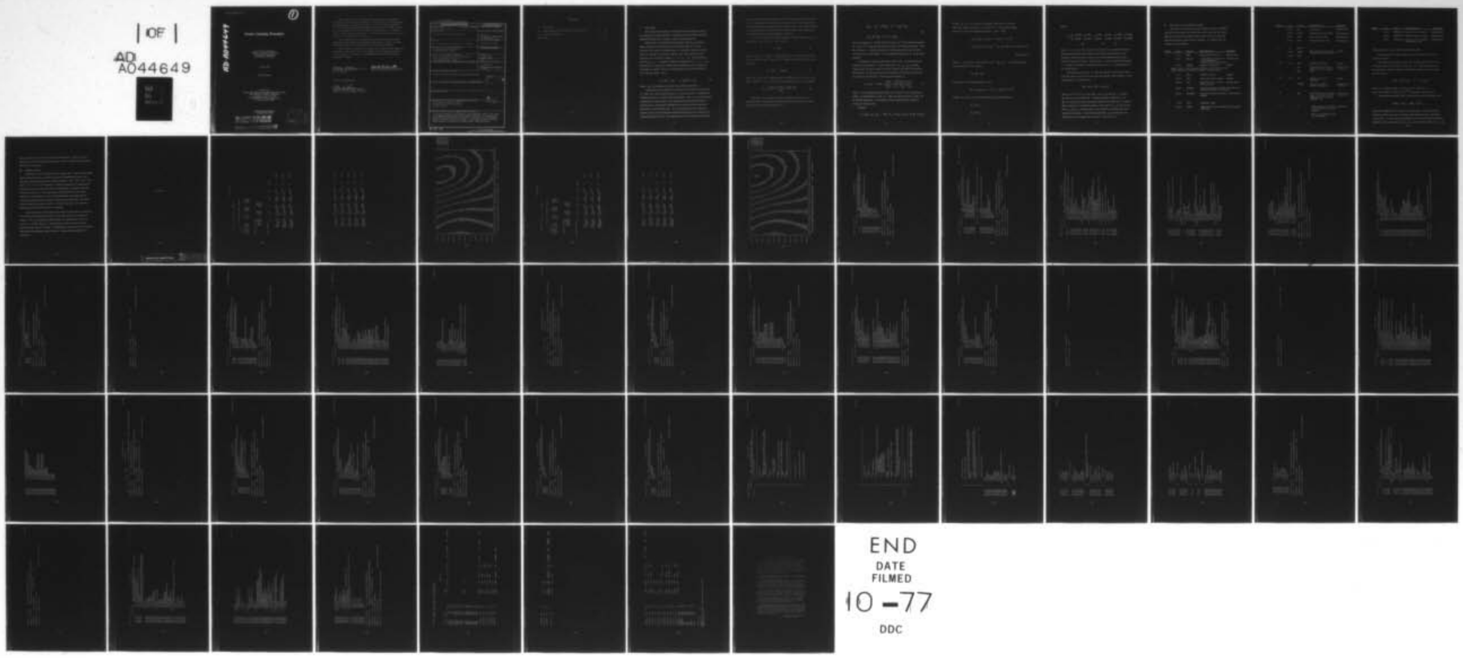

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AD-A044649

Source Locating Procedure

Space Sciences Laboratory
The Ivan A. Getting Laboratories
The Aerospace Corporation
El Segundo, Calif. 90245

15 July 1977

Interim Report

Prepared for
SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
Los Angeles Air Force Station
P.O. Box 92960, Worldway Postal Center
Los Angeles, Calif. 90009

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This interim report was submitted by The Aerospace Corporation, El Segundo, CA 90245, under Contract No. F04701-76-C-0077 with the Space and Missile Systems Organization, Deputy for Advanced Space Programs, P.O. Box 92960, Worldway Postal Center, Los Angeles, CA 90009. It was reviewed and approved for The Aerospace Corporation by G. A. Paulikas, Director, Space Sciences Laboratory. Lieutenant Dara Batki was the project Officer for Advanced Space Programs.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Dara Batki

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Least Squares Fitting Technique
Measurement of Photo Emission
Target Location

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computer program is presented for estimating the location of a target from satellite measurements of its photon emission. The satellite is assumed to have a number of detectors mounted at various orientations which monitor the photon count rates. From these the most probable target location is inferred by a least squares fitting technique.

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CONTENTS

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I. ANALYSIS

We consider the problem of inferring the most probable location of a target given measurements of its photon emission collected from a satellite equipped with a number of planar photon detectors.

Specifically, we assume that the satellite carries n_D detectors whose respective orientations are given by the angle of elevation from the nadir and the azimuthal angle α measured counter-clockwise from the satellite's direction of motion. The count rates from the detectors are recorded at times t_i, $i = 1, 2, \ldots, n_T$. This provides a total of $n_S = n_D \cdot n_T$ positive numbers designated by C_i, $i = 1, \ldots, n_S$. Because the C_i include an unknown factor depending on the strength of the target we replace then by a corresponding set of scaled quantities S_i having unit mean. Thus,

$$S_i = \kappa(C_i - C_B); \qquad \kappa = n_S/\Sigma(C_i - C_B) \tag{1}$$

where C_B is the background count rate (assumed isotropic).

The position of the satellite is assumed to be known at each instant t_i. Thus, for a given target location it is clearly possible to compute the scaled quantities S_i purely from the geometry: each S_i will be inversely proportional to the distance to the target and directly proportional to a known function of the angle subtended at the detector by the target and the normal to the detector face. For an ideal detector this function is just the cosine, but an empirical response function given in tabular form can equally well be used. The actual location of the target is taken to be

the one that minimizes the differences between the computed and measured S_i. The computation takes the form of a series of successive approximations starting from an initial 'guessed' target location. This initial location is conveniently taken to be at the point on the surface of the earth that is viewed by the detector with the highest count rate.

We describe the location of the target by giving its latitude λ_T, and its longitude μ_T. Then, in vector notation

$$S = f(\Gamma) \tag{2}$$

where $S = \{S_i, i = 1, n_S\}$, $\Gamma = \{\lambda_T, \mu_T\}$ and f is a non-linear function given by the geometry. Equation (2) is approximated locally by the linear equations

$$S = f(\Gamma_0) + G(\Gamma_0)\Delta\Gamma \tag{3}$$

where Γ_0 is the current approximation and $\Delta\Gamma$ the first correction, and $G(\Gamma) = \partial f/\partial\Gamma$ is a $n_S \times 2$ matrix of forward differences. For example

$$G_{12} = \frac{f_1(\lambda_T, \mu_T + \Delta\mu_T) - f_1(\lambda_T, \mu_T)}{\Delta\mu_T} \tag{4}$$

Equations (3) constitute a set of n_S algebraic equations in 2 unknowns whose least-squares solution forms the basis for the iterative solution of the non-linear equations (2)

$$\Gamma_{k+1} = \Gamma_k + [G^T(\Gamma_k) \cdot C^{-1} \cdot G(\Gamma_k)]^{-1} E_k$$

$$E_k = G^T(\Gamma_k) \cdot C^{-1} \cdot [S - f(\Gamma_k)] \tag{5}$$

Here the subscript k denotes the kth iteration, G^T is the matrix transpose of G and C^{-1} is the inverse of the covariance of the measurements. Since the variance is equal to the mean for a Poisson process and since the count rates are uncorrelated, C is a diagonal matrix with C_i on the main diagonal.

It remains to determine the form of $f(\Gamma)$ in Eq. (2) from which the elements of the matrix G can be calculated. Let r_T, r_S, r_D denote respectively the radius vectors from the center of the earth to the target, the satellite, and the intersection of the surface of the earth with the line-of-sight from the detector. Then for each estimate f_i

$$f_i = \kappa \cos \measuredangle TSD = \kappa \frac{[(r_S)_i - r_T]\,[(r_S)_i - (r_D)_i]}{\left|(r_S)_i - r_T\right| \left|(r_S)_i - (r_D)_i\right|} \tag{6}$$

where κ is a normalizing factor which, for any given set of n_S measurements, is determined as in Eq. (1). Here the cosine function is used, but, as already mentioned, it can equally well be replaced by an empirical function in tabular form.

Clearly

$$r_T = \left\{x_T, y_T, z_T\right\} = \left\{\cos \lambda_T \cos \mu_T, \cos \lambda_T \sin \mu_T, \sin \lambda_T\right\} .$$

To find r_S, r_D it is convenient to express them first in a primed coordinate system such that r_S is along the x' axis and the angular velocity vector of the satellite along the z' axis. Then

$$r'_S = \left| x'_S, y'_S\, z'_S \right| = (a + h_S) \left| 1, 0, 0 \right|$$

$$r'_D = \left| x'_D, y'_D, z'_D \right| = \left| a + h_S - SD \cos\epsilon,\ SD \sin\epsilon \cos\alpha, \right.$$

$$\left. SD \sin\epsilon \sin\alpha \right|$$

where a is the radius of the earth and $SD = \left| r_D - r_S \right|$ is readily obtained by squaring the vector relation

$$\vec{r}_S + \vec{SD} = \vec{r}_D$$

and solving the resulting quadratic to get

$$SD = (a + h_S) \cos\epsilon - [a^2 - (a + h_S)^2 \sin^2 \epsilon\,]^{1/2} \quad .$$

Finally, the values in the unprimed system can be obtained by

$$r_S = T\, r'_S$$

$$r_D = T\, r'_D$$

where

$$T = \begin{pmatrix} u_x \cos\alpha + u_y \sin\alpha, & v_x \cos\alpha + v_y \sin\alpha, & w_x \cos\alpha + w_y \sin\alpha \\ -u_x \sin\alpha + u_y \cos\alpha, & -v_x \sin\alpha + v_y \cos\alpha, & -w_x \sin\alpha + w_y \cos\alpha \\ u_z, & v_z, & w_z \end{pmatrix}$$

Here u, v, w are a triad of unit vectors given by the satellite ephemeris program which specify the position and velocity of the satellite in an inertial coordinate system, and α is the corresponding angle through which the earth has rotated. In particular, u points towards the satellite, v is along its horizontal component of motion and w is perpendicular to its orbital plane.

The result given by Eq. (6) must be checked in each case to make sure the target is not over the horizon with respect to the satellite. From the geometry it is clear that if

$$HI = \cos \sphericalangle TOS - \sin(\delta - \beta)$$

where $\cos\delta = a/(a + h_T)$ and $\sin\beta = a/(a + h_S)$, then $HI < 0$ implies the target is over the horizon. Similarly negative values for f_i in Eq. (6) indicate radiation entering the detector from the rear. In both of these cases the corresponding entries in the matrix G_{ij} are set to zero. Here h_S and h_T are the heights of the satellite and target above the surface of the earth. (Unless input differently, h_T is assumed to be 50 km, above which height there is about 1 g/cm^2 of air.)

II. Description of data input and output.

The data are read by subroutines DATIN, START and EPHM. The latter subroutines are called from DATIN and read the orbital element sets provided by GWC; DATIN reads the input cards that specify the detector positions and readings. A complete data set consists of the following:

CARD	COL	VALUE	DESCRIPTION	FORMAT
1	1-10	ERR	Background count rate	floating point
	11-20	EFLAG	= 0 (or blank), means read orbit element set ≠ 0, new flight not specified	floating point
	21-22	MAXIT	number of iterations	integer
(cards 2 and 3 are read when EFLAG = 0 and are the 2-line orbit element set formatted by Space Defense Center)				
2	3-7	ISAT	satellite number	integer
	19-20	IYR	epoch year (last 2 digits)	integer
	21-32	DAY	epoch day (day + fraction of day of year)	floating point
	34-43	XNDOT	1 st time derivative of mean motion or Ballistic coefficient.	floating point
	45-52	XNDDOT	2 nd time derivative of mean motion.	floating point
3	9-16	XIO	inclination (deg)	
	18-25	ASNO	right ascension of ascending node (deg)	floating point

CARD	COL	VALUE	DESCRIPTION	FORMAT
	27-33	EO	eccentricity	floating point
	35-42	ARGO	argument of perigee (deg)	floating point
	44-51	XMO	mean anomaly (deg)	floating point
	53-53	XNO	mean motion (rev/day)	floating point
4	1-5	KDAY		
	6-10	KMON	day, month and year (last 2 digits) of data acquisition	integer
	11-15	KYR		
5*	1-2	ND	number of detectors	integer
		AZ EL	azimuth and elevation of detectors, read in pairs (deg)	floating point (8F7.0)
6*	1-2	NT	number of detector readings	integer
		TIMES	time(s) (seconds) of detector readings	floating point (8F7.0)
7*		SM	NT x ND detector readings input so that the first NT readings are for the first detector, etc.	floating point (8F10.0)
8	1	D	= 1HD, program calculates initial estimate of target location = 1H , use following values as initial guess	alphabetic

CARD	COL	VALUE	DESCRIPTION	FORMAT
	2-11	TARLOC (1)	latitude (deg) of target	floating point
	12-21	TARLOC (2)	longitude (deg) of target	floating point
	22-31	TARLOC (3)	altitude (km) if different from preset value	floating point

*Additional cards may be necessary for these inputs.

The program ends when a blank card is encountered as the first card of a data set.

The output of the program at the kth iteration will consist of the current estimate of the target location λ_T, μ_T representing latitude and longitude in degrees together with the determinant of the covariance of error matrix

$$COV = \kappa \, [G^T(\Gamma_k) \, . \, C^{-1} \, . \, G(\Gamma_k)]^{-1}$$

where κ is defined in Eq. (1) and G, and C after Eq. (5). Also, the residual $R = [\Sigma(S_i - f_i)^2]^{1/2}$ is printed at each iteration.

Note that the procedure tries to minimize the positive definite form

$$Q(\lambda_T \, , \, \mu_T) \; = \; \Sigma(S_i - f_i)^2 / S_i$$

giving the weighted sum of squares of the residuals. In some cases the iteration scheme may fail to converge if the data and/or the initial guess are too poor. In such cases it is helpful to have an isoresidual contour plot obtained from a tabulation of $Q(\lambda_T, \mu_T)$ over a grid of values of λ_T, μ_T.

Such a tabulation is provided at the end of the printout. From it one can determine if any well defined minima exist, and if so select the most likely one as the initial guess.

III. Sample Problem

Following are the printouts from two sample runs. The first uses ideal data to test the program, and the second uses simulated real data. Four detectors are placed at azimuth, elevation angles of (45°, 30°), (135°, 30°), (225°, 30°), (315°, 30°); the target is placed at latitude 30°, longitude 20°. In the first run count rates are input corresponding to 3 satellite locations taken 2 seconds apart. The count rates are proportional to the number obtained by computing the cosine of the angle between the target and the detector normal and then dividing it by the square of the range. The background count rate is taken to be zero. From the printout it is clear that the program finds the target after 2 iterations.

In the second run a set of physically realistic count rates are selected from Poisson's distribution having the count rates of the first example as means. This is accomplished approximately by replacing the count rate C_i by $C_i + Z_i \sqrt{C_i}$ where Z_i is taken from a table of normal deviates with zero mean and unit variance. A background count rate of 10 is assumed. We see that the program comes to within 1 degree of the target after 2 iterations.

APPENDIX

NEW

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```
                                                      LOCATOR RUN    1

   DETECTOR COUNT RATES FOR    8/10/74


           UT  70582.00  70702.00  70822.00

   (AZ,EL)

 ( 45.0, 30.0)     146.8     514.6     173.7
 (135.0, 30.0)      76.1     441.3     322.9
 (225.0, 30.0)      64.7     450.6     516.3
 (315.0, 30.0)     205.4     524.2     167.1



SATELLITE POSITION
               UT        LAT       LON
          70582.00      36.44     22.59
          70702.00      31.49     20.49
          70822.00      24.51     18.60



TARGET ESTIMATE
               LAT      26.67     LON     16.21     ALT     15.00



        ITER    0     LAT       26.67     LON      16.21     HT      15.00
        DETERMINANT=    0.10932E 06   0.16214E 02
        RESIDUAL=      3.905

        ITER    1     LAT       30.10     LON      19.72     HT      15.00
        DETERMINANT=    0.79849E 05   0.19714E 02
        RESIDUAL=      3.930

        ITER    2     LAT       30.00     LON      20.00     HT      15.00
        DETERMINANT=    0.81263E 05   0.19999E 02
        RESIDUAL=      3.929
```

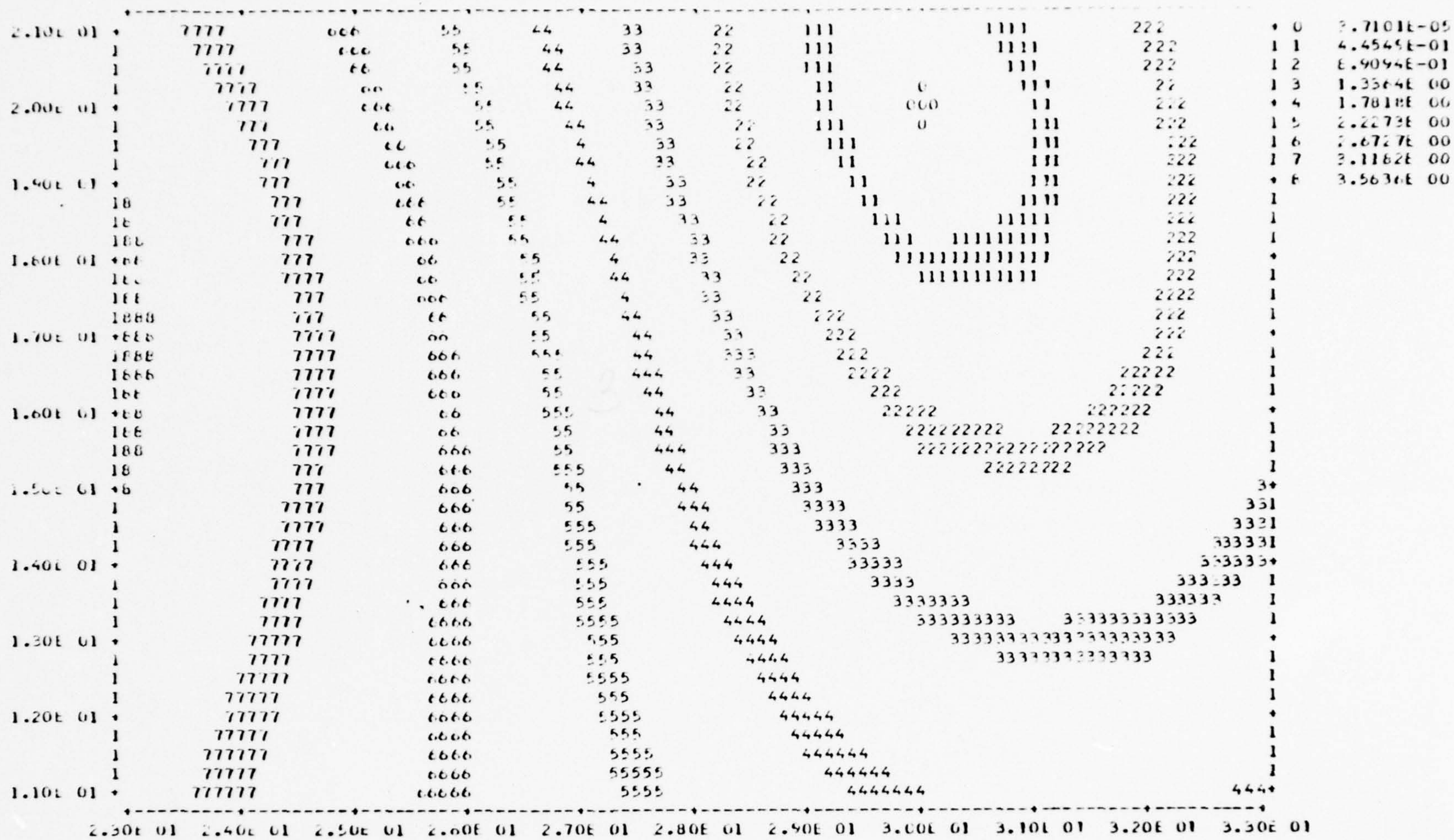
```
ITER    3      LAT      30.00      LON      20.00      HT      15.00
DETERMINANT=    0.81216E 05    0.20000E 02
RESIDUAL=      3.929

ITER    4      LAT      30.00      LON      20.00      HT      15.00
DETERMINANT=    0.81234E 05    0.20000E 02
RESIDUAL=      3.929

ITER    5      LAT      30.00      LON      20.00      HT      15.00
DETERMINANT=    0.81217E 05    0.20000E 02
RESIDUAL=      3.929

ITER    6      LAT      30.00      LON      20.00      HT      15.00
DETERMINANT=    0.81226E 05    0.20000E 02
RESIDUAL=      3.929

ITER    7      LAT      30.00      LON      20.00      HT      15.00
DETERMINANT=    0.81226E 05    0.20000E 02
RESIDUAL=      3.929
```



ISORESIDUAL CONTOURS CENTERED ON TARGET GUESS (LAT,LON) OF 28.00 16.00 DEGREES

```
                                                              LOCATOR RUN    2

    DETECTOR COUNT RATES FOR    8/10/74


          UT  70582.00  70702.00  70822.00

   (AZ,EL)

( 45.0, 30.0)      188.0      541.0      155.0
(135.0, 30.0)       74.0      461.0      337.0
(225.0, 30.0)       61.0      463.0      316.0
(315.0, 30.0)      167.0      561.0      161.0



SATELLITE POSITION
               UT          LAT         LON
         70582.00        38.44       22.59
         70702.00        31.49       20.49
         70822.00        24.51       18.60



TARGET ESTIMATE
               LAT      28.67      LON      16.21      ALT      15.00



        ITER    0     LAT      28.67      LON       16.21      HT      15.00
        DETERMINANT=    0.10432E 06    0.16214E 02
        RESIDUAL=     3.905

        ITER    1     LAT      30.17      LON       20.12      HT      15.00
        DETERMINANT=    0.75871E 05    0.20115E 02
        RESIDUAL=     3.437

        ITER    2     LAT      30.00      LON       20.08      HT      15.00
        DETERMINANT=    0.80759E 05    0.20077E 02
        RESIDUAL=     3.930
```

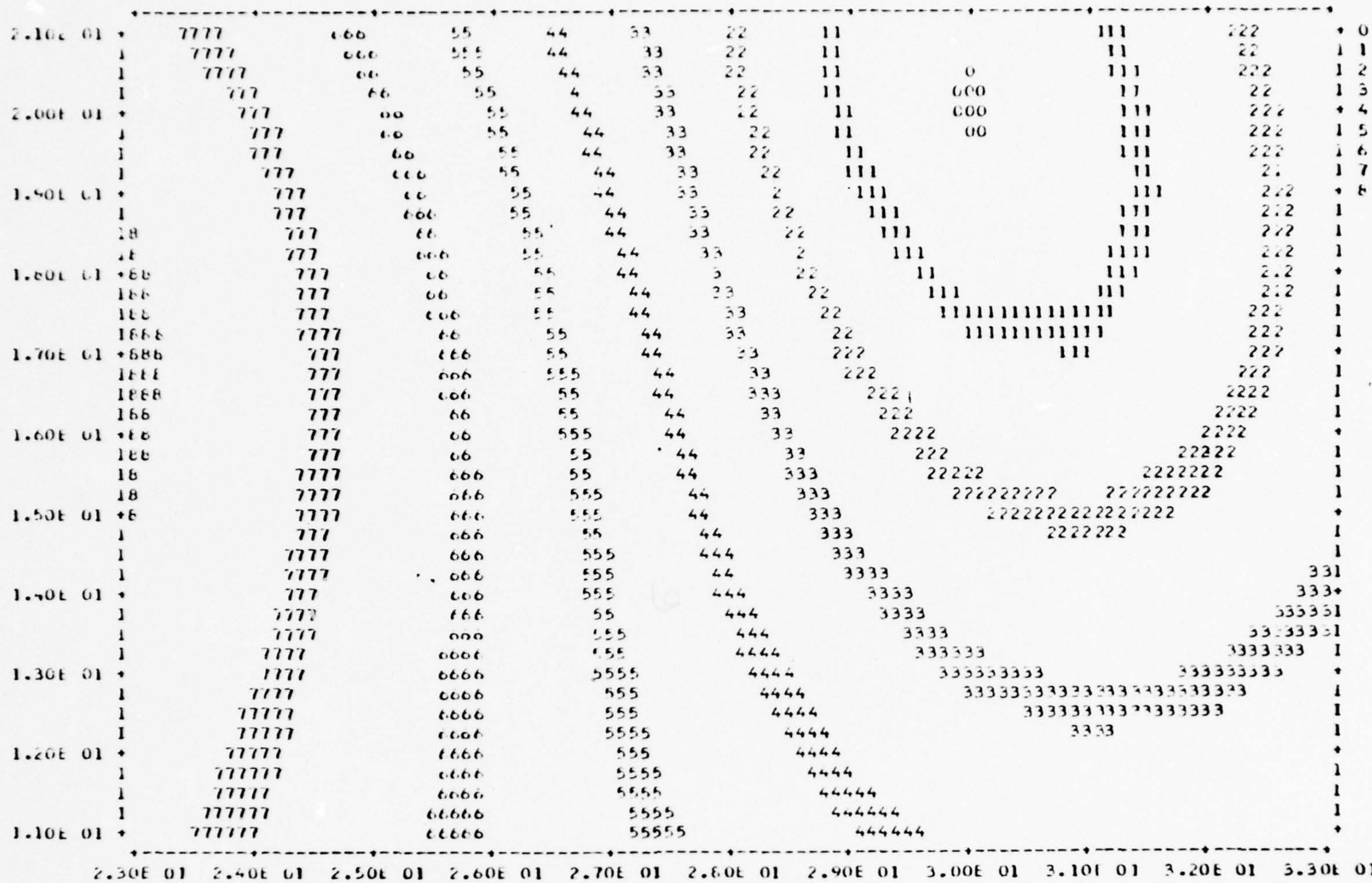
```
ITER    3      LAT       30.02      LON        20.08      HT        15.00
DETERMINANT=     0.60059E 05     0.20079E 02
RESIDUAL=        3.931

ITER    4      LAT       30.02      LON        20.08      HT        15.00
DETERMINANT=     0.60151E 05     0.20080E 02
RESIDUAL=        3.931

ITER    5      LAT       30.02      LON        20.08      HT        15.00
DETERMINANT=     0.60139E 05     0.20080E 02
RESIDUAL=        3.931

ITER    6      LAT       30.02      LON        20.08      HT        15.00
DETERMINANT=     0.60129E 05     0.20080E 02
RESIDUAL=        3.931

ITER    7      LAT       30.02      LON        20.08      HT        15.00
DETERMINANT=     0.60113E 05     0.20080E 02
RESIDUAL=        3.931
```



SYMBOL TABLE

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2	1.0803E 00
3	1.5110E 00
4	1.9416E 00
5	2.3723E 00
6	2.8029E 00
7	3.2335E 00
8	3.6642E 00

ISORESIDUAL CONTOURS CENTERED ON TARGET GUESS (LAT,LON) OF 28.00 16.00 DEGREES

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  ISN 0002          COMMON DATURB(5),ND,AZ(10),EL(10),NT,TIMES(20),SM(200),
                   *T/ELEC(3),ERR
  ISN 0003          COMMON/CONST/RADS,DEG,PI,RF
  ISN 0004          COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
  ISN 0005          COMMON/DAY/IDAYP
  ISN 0006          COMMON/GUESS/GUESSO(3)
  ISN 0007          PI=4.*ATAN(1.)
  ISN 0008          RADS=PI/180.
  ISN 0009          DEG=180./PI
  ISN 0010          RF=10800./PI
  ISN 0011        1 CALL DATIN
  ISN 0012          CALL REFINE
  ISN 0013          CALL GRID
  ISN 0014          GO TO 1
  ISN 0015          END

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*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       14 ,PROGRAM SIZE =       334

*STATISTICS*  NO  DIAGNOSTICS GENERATED

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LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                                   DATE  77.021/09.31.01

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                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002              SUBROUTINE ALLEPH
  ISN 0003              REAL*8 UU,VV,WW,DDAYS
  ISN 0004              COMMON SATURD(5),ND,AZ(10),EL(10),NT,TIMES(20)
  ISN 0005              COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
  ISN 0006              COMMON/CONST/RADS
  ISN 0007              COMMON/DAY/ISECP
  ISN 0008              COMMON/UVW/UU(3),VV(3),WW(3)
  ISN 0009              COMMON/SATPOS/SATPOS(20,2)
                  C
                  C GENERATE SATELLITE POSITION VECTORS FOR EACH TIME READINGS ARE MADE
                  C
  ISN 0010              DO 5 I=1,NT
  ISN 0011              CALL EPHM1(TIMES(I),SATPOS(I,2),ALT(I),SATPOS(I,1))
  ISN 0012              DO 4 J=1,3
  ISN 0013              U(J,I)=UU(J)
  ISN 0014              V(J,I)=VV(J)
  ISN 0015            4 W(J,I)=WW(J)
  ISN 0016              DDAYS=ISECP+TIMES(I)/86400.D0
  ISN 0017              ALPHA(I)=ARIES(DDAYS)
  ISN 0018            5 CONTINUE
  ISN 0019              RETURN
  ISN 0020              END

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*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

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*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                       553K BYTES OF CORE NOT USED
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  ISN 0002             SUBROUTINE DATIN
  ISN 0003             COMMON SATORB(5),ND,AZ(10),EL(10),NT,TIMES(20),SM(200),
                      *TABLE(3),BKR
  ISN 0004             COMMON/CONST/RADS,DEG,PI,RE
  ISN 0005             COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
  ISN 0006             COMMON/ITER/MAXIT
  ISN 0007             COMMON/SATPOS/SATPOS(20,2)
  ISN 0008             COMMON/GUESS/GUESSO(3)
  ISN 0009             DIMENSION XYZ(3)
  ISN 0010             DATA BLANK/1H /
  ISN 0011             DATA NRUN/0/
                 C GIVEN BACKGROUND COUNT RATE DEFINED BY...
  ISN 0012             READ(5,499)BKR,EFLAG,MAXIT
  ISN 0013             IF(BKR .LT. 0.) GO TO 1000
  ISN 0015             NRUN=NRUN+1
  ISN 0016             WRITE(6,504) NRUN
                 C EFLAG=0 MEANS READ SATELLITE ELEMENT SET
  ISN 0017             IF(EFLAG .EQ. 0.) CALL START
  ISN 0019             IF(EFLAG .NE. 0.) SATORB(3)=SATORB(3)*DEG
  ISN 0021           2 CALL EPHM(SATORB(1),SATORB(2),SATORB(4),SATORB(5))
  ISN 0022             SATORB(2)=SATORB(2)*RADS
  ISN 0023             SATORB(3)=SATORB(3)*RADS
  ISN 0024             SATORB(5)=SATORB(5)*RADS
                 C ...AND GIVEN AZIMUTH AND ELEVATION PAIRS FOR ND DETECTORS...
  ISN 0025             READ(5,502) ND,(AZ(I),EL(I),I=1,ND)
                 C READ TIMES...
  ISN 0026             READ(5,502) NT,(TIMES(I),I=1,NT)
  ISN 0027             CALL ALLEPH
                 C...AT WHICH DETECTORS TAKE NS (=NT*ND) READINGS...
  ISN 0028             NS=NT*ND
  ISN 0029             READ(5,500) (SM(I),I=1,NS)
                 C SUBTRACT BACKGROUND
  ISN 0030             DO 8 I=1,NS
  ISN 0031           8 SM(I)=SM(I)-BKR
  ISN 0032             WRITE(6,501) (TIMES(I),I=1,NT)
  ISN 0033             WRITE(6,508)
  ISN 0034             DO 7 I=1,ND
```

```
ISN 0035          WRITE(6,503) AZ(I),EL(I),(SM(J+I*NT-NT),J=1,NT)
ISN 0036          AZ(I)=AZ(I)*FACS
ISN 0037        7 EL(I)=EL(I)*FACS
ISN 0038          WRITE(6,505) (TIMES(I),SATPOS(I,1),SATPOS(I,2),I=1,NT)
ISN 0039          SUM=0.
ISN 0040          RMAX=0.
ISN 0041          DO 5 I=1,NS
ISN 0042        5 SUM=SUM+SM(I)
ISN 0043          ERR=ERR/SUM*NS
        C FINALLY, READ ZEROTH ESTIMATE OF TARGET LOCATION (OR USE
        C DEFAULT)
ISN 0044          READ(5,507) L,TARLOC
        C NORMALIZE COUNT RATES
ISN 0045          DO 6 I=1,NS
ISN 0046          SM(I)=SM(I)/SUM*NS
ISN 0047          IF(SM(I) .LE. RMAX) GO TO 6
ISN 0049          RMAX=SM(I)
ISN 0050          MAX=I
ISN 0051        6 CONTINUE
ISN 0052          IF(L .EQ. BLANK) GO TO 10
        C ZEROTH ESTIMATE OF TARGET LOCATION IS SPOTVIEWED BY DETECTOR
        C WITH MAXIMUM RESPONSE
ISN 0054          I1=1+MAX/NT
ISN 0055          IF(MOD(MAX,NT) .EQ. 0) I1=I1-1
ISN 0057          I2=MOD(MAX,NT)
ISN 0058          IF(I2 .EQ. 0) I2=NT
ISN 0060          CALL SPOTVU (AZ(I1),EL(I1),XYZ,ALT(I2))
ISN 0061          CALL ROT3(XYZ,I2)
ISN 0062          X=XYZ(1)
ISN 0063          Y=XYZ(2)
ISN 0064          Z=XYZ(3)
ISN 0065          TARLOC(1)=ATAN2(Z,ABS(X*(1.+Y*Y/X/X)**.5))*DEG
ISN 0066          TARLOC(2)=ATAN2(Y,X)*DEG
ISN 0067          IF(TARLOC(2) .LT. 0.) TARLOC(2)=TARLOC(2)+360.
        C TARGET HEIGHT IS SET AT 15 NM
ISN 0069       10 CONTINUE
ISN 0070          IF(TARLOC(3) .EQ. 0) TARLOC(3)=50.
ISN 0072          WRITE(6,506) TARLOC
ISN 0073          GUESSO(1)=TARLOC(1)
```

```
ISN 0074          COESSC(2)=TAFLCC(2)
ISN 0075          COESSC(3)=TARLCC(3)
ISN 0076          TARLCC(1)=TARLCC(1)*RADS
ISN 0077          TARLCC(2)=TARLCC(2)*RADS
ISN 0078          RETURN
ISN 0079     1000 WRITE(6,1001)
ISN 0080          STOP 1000
ISN 0081     1001 FORMAT(10X,17HE N D   O F   R U N  )
ISN 0082      499 FORMAT(2F10.0,I10)
ISN 0083      500 FORMAT(8F10.0)
ISN 0084      501 FORMAT(I13,'UT',10F10.2)
ISN 0085      502 FORMAT(I2,(8F7.6))
ISN 0086      503 FORMAT(2X,1H(,F5.1,1H,,F5.1,1H),10F10.1)
ISN 0087      504 FORMAT(1H1,T50,'LOCATOR RUN',I5)
ISN 0088      505 FORMAT(////,1X,'SATELLITE POSITION'/T19,'UT',T28,'LAT',T38,'LON'/
                 *  (10X,3F10.2))
ISN 0089      506 FORMAT(////1X,'TARGET ESTIMATE'/T16,'LAT',F10.2,5X,'LON',F10.2,
                 *    5X,'ALT',F10.2)
ISN 0090      507 FORMAT(A1,3F10.0)
ISN 0091      508 FORMAT(/4X,'(A2,EL)'/)
ISN 0092          END

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =    91 ,PROGRAM SIZE =      2214

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                   541K BYTES OF CORE NOT USED
```

```
COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                         SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002          SUBROUTINE DETECT(AZ,EL,S,HS,INX)
            C RETURNS OUTPUT OF A SINGLE DETECTOR
ISN 0003          COMMON DUM(247),RLAMT,RMUT,HT
ISN 0004          COMMON/CONST/RADS,DEG,PI,RE
ISN 0005          DIMENSION XT(3),SD(3),ST(3),XD(3)
ISN 0006          DIMENSION XS(3)
ISN 0007          DIMENSION DR(3)
ISN 0008          S=0.
ISN 0009          CALL SPDIVO (AZ,EL,XD,HS)
ISN 0010          CALL ROT3(XD,INX)
ISN 0011          REHT=RE+HT
ISN 0012          REHS=RE+HS
ISN 0013          XS(1)=REHS
ISN 0014          XS(2)=0.
ISN 0015          XS(3)=0.
ISN 0016          CALL ROT3(XS,INX)
ISN 0017          COSL=COS(RLAMT)
ISN 0018          XT(1)=REHT*COSL*COS(RMUT)
ISN 0019          XT(2)=REHT*COSL*SIN(RMUT)
ISN 0020          XT(3)=REHT*SIN(RLAMT)
ISN 0021          HI=DOT(XT,XS)/(REHT*REHS)
ISN 0022          EPS=SIN(ASIN(RE/REHS)-ACOS(RE/REHT))
ISN 0023          IF(EPS .GT. HI) RETURN
ISN 0025          DO 5 I=1,3
ISN 0026          DR(I)=XS(I)-XT(I)
ISN 0027          SD(I)=XD(I)-XS(I)
ISN 0028        5 ST(I)=XT(I)-XS(I)
ISN 0029          RRCOOR=1./DOT(DR,DR)
ISN 0030          S=DOT(SD,ST)/SQRT(DOT(SD,SD)*DOT(ST,ST))
ISN 0031          ANGLE=ACOS(S)
ISN 0032          S=RRCOOR*RESPON(ANGLE)
ISN 0033          IF(S .LT. 0.) S=0.
ISN 0035          RETURN
ISN 0036          END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
```

```
LEVEL 21.7 ( JAN 73 )                         OS/360  FORTRAN H                              DATE  77.021/09.31.26

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002            FUNCTION DOT(X,Y)
  ISN 0003            DIMENSION X(1),Y(1)
  ISN 0004            DOT=X(1)*Y(1)+X(2)*Y(2)+X(3)*Y(3)
  ISN 0005            RETURN
  ISN 0006            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        5 ,PROGRAM SIZE =       264

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    557K BYTES OF CORE NOT USED
```

```
*STATISTICS*     SOURCE STATEMENTS =      3* ,PROGRAM SIZE =      1224
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                              553K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                           DATE  77.021/09.31.31

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002            SUBROUTINE OUTPUT(S)
  ISN 0003            COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
  ISN 0004            COMMON SATURE(5),ND,AZ(10),EL(10),NT,TIMES(20),SM(200),
                     *TABLEC(3),ERR
  ISN 0005            DIMENSION S(1),
  ISN 0006            SUM=0.
  ISN 0007            DO 10 I=1,NT
  ISN 0008            DO 10 J=1,ND
  ISN 0009            K=I+NT*(J-1)
  ISN 0010            CALL DETOUT(AZ(J),EL(J),S(K),ALT(I),1)
  ISN 0011         10 SUM=SUM+S(K)
  ISN 0012            NS=ND*NT
  ISN 0013            DO 20 I=1,NS
  ISN 0014            IF(SUM .EQ. 0.) GO TO 20
  ISN 0016            S(I)=AMAX1(0.,S(I)/SUM)*NS
  ISN 0017         20 CONTINUE
  ISN 0018            RETURN
  ISN 0019            END
*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      18 ,PROGRAM SIZE =      578

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                   553K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                              DATE  77.021/04.31.36

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002          SUBROUTINE REFINE
ISN 0003          COMMON SATCRD(5),NL,AZ(10),EL(10),NT,TIMES(20),SM(200),
                 *TARLOC(3),ERR
ISN 0004          COMMON/CONST/RADS,DEG,PI,RE
ISN 0005          DIMENSION SC(200),SPL(200),SPM(200),GRAD(200,2),
                 * COV(2,2),TEMP(3),DEL(2)
ISN 0006          DIMENSION TERR(2),IW1(2),IW2(2)
ISN 0007          COMMON/ITER/MAXIT
ISN 0008          DATA TERR/2*0.0/
ISN 0009          ITER=0
ISN 0010          NS=NL*NT
ISN 0011          RINC=0.1*RADS
ISN 0012          WRITE(6,101)
ISN 0013        1 CONTINUE
ISN 0014          TEMP(1)=TARLOC(1)*DEG
ISN 0015          TEMP(2)=TARLOC(2)*DEG
ISN 0016          TEMP(3)=TARLOC(3)
ISN 0017          WRITE(6,101)
ISN 0018          WRITE(6,100) ITER,TEMP
ISN 0019          CALL OUTPUT(SC)
ISN 0020          TARLOC(1)=TARLOC(1)+RINC
ISN 0021          CALL OUTPUT(SPL)
ISN 0022          TARLOC(1)=TARLOC(1)-RINC
ISN 0023          TARLOC(2)=TARLOC(2)+RINC
ISN 0024          CALL OUTPUT(SPM)
ISN 0025          TARLOC(2)=TARLOC(2)-RINC
ISN 0026          DO 10 I=1,NS
ISN 0027          GRAD(I,1)=(SPL(I)-SC(I))/RINC
ISN 0028          GRAD(I,2)=(SPM(I)-SC(I))/RINC
ISN 0029       10 SC(I)=SM(I)-SC(I)
ISN 0030          DO 20 I=1,2
ISN 0031          DO 20 J=1,2
ISN 0032          COV(I,J)=0.
ISN 0033          DO 20 K=1,NS
ISN 0034          COV(I,J)=COV(I,J)+GRAD(K,I)*GRAD(K,J)
ISN 0035       20 CONTINUE
ISN 0036          CALL MINV(COV,2,TEMP,IW1,IW2)
```

```
ISN 0037            DO 50 I=1,2
ISN 0038            DEL(I)=0.
ISN 0039            DO 40 J=1,NS
ISN 0040            DO 40 K=1,2
ISN 0041            DEL(I)=DEL(I)+COV(I,K)*GRAD(J,K)*SC(J)
ISN 0042         40 CONTINUE
ISN 0043         50 CONTINUE
ISN 0044            RSDL=0.
ISN 0045            DO 55 I=1,NS
ISN 0046         55 RSDL=RSDL+(SM(I)-SC(I))**2
ISN 0047            RSDL=SQRT(RSDL)
ISN 0048            WRITE(6,110) TEMP(1),TEMP(2),RSDL
ISN 0049            ITER=ITER+1
ISN 0050            IF(ITER .GT. MAXIT) RETURN
ISN 0052            DO 60 I=1,2
ISN 0053         60 TARLOC(I)=TARLOC(I)+DEL(I)
ISN 0054            GO TO 1
ISN 0055        100 FORMAT(10X,4HITER,I5,5X,4HLAT ,F10.2,5X,4HLON ,F10.2,5X,
                   *5HHT  ,F10.2)
ISN 0056        101 FORMAT(/)
ISN 0057        110 FORMAT(10X,'DETERMINANT=',2E15.5/10X,'RESIDUAL=',F10.3)
ISN 0058            END
```

```
              ERROR NO   LEVEL        ERROR MESSAGE
    NAME   TERR   IEK3071     04      THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.
*OPTIONS IN EFFECT*      NAME= MAIN,OPT=02,LINECNT=41,SIZE=0000K,
*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
*STATISTICS*     SOURCE STATEMENTS =      57 ,PROGRAM SIZE =     5322
*STATISTICS*    1 DIAGNOSTICS GENERATED, HIGHEST SEVERITY CODE IS  4
****** END OF COMPILATION ******                                        641K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                          OS/360  FORTRAN H                          DATE  77.021/09.31.45

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002          FUNCTION RESPON(A)
  ISN 0003          RESPON=COS(A)
  ISN 0004          RETURN
  ISN 0005          END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        4 ,PROGRAM SIZE =       226

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                   557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                              OS/360  FORTRAN H                                    DATE  77.021/09.31.49

            COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                               SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002              SUBROUTINE ROTS(X,I)
  ISN 0003              DIMENSION X(3)
  ISN 0004              COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
  ISN 0005              DIMENSION T(3),S(3)
  ISN 0006              COSAL=COS(ALPHA(I))
  ISN 0007              SINAL=SIN(ALPHA(I))
  ISN 0008              T(1)=U(1,I)*COSAL+U(2,I)*SINAL
  ISN 0009              T(2)=V(1,I)*COSAL+V(2,I)*SINAL
  ISN 0010              T(3)=W(1,I)*COSAL+W(2,I)*SINAL
  ISN 0011              S(1)=DOT(T,X)
  ISN 0012              T(1)=-U(1,I)*SINAL+U(2,I)*COSAL
  ISN 0013              T(2)=-V(1,I)*SINAL+V(2,I)*COSAL
  ISN 0014              T(3)=-W(1,I)*SINAL+W(2,I)*COSAL
  ISN 0015              S(2)=DOT(T,X)
  ISN 0016              T(1)=U(3,I)
  ISN 0017              T(2)=V(3,I)
  ISN 0018              T(3)=W(3,I)
  ISN 0019              S(3)=DOT(T,X)
  ISN 0020              DO 11 II=1,3
  ISN 0021           11 X(II)=S(II)
  ISN 0022              RETURN
  ISN 0023              END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       22 ,PROGRAM SIZE =       690

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                         DATE  77.021/09.31.58

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
 ISN 0002             SUBROUTINE EPHM(TIME,RLON,ALT,RLAT)
 ISN 0003             REAL*4 CX,CY,CZ,VX,VY,VZ,WX,WY,WZ
 ISN 0004             REAL*8 RX,RY,RZ,R,TDAY
 ISN 0005             COMMON/CVW/CX,CY,CZ,VX,VY,VZ,WX,WY,WZ
 ISN 0006             COMMON/RR/RX,RY,RZ,R
 ISN 0007             COMMON/DAY/TDAYP
 ISN 0008             REAL*8 A,RTOD
 ISN 0009             DATA RTOD/57.295779513D0/
 ISN 0010             DATA AE/6378.16/
          C
          C
 ISN 0011             READ(5,1) KDAY,KMON,KYR,RHR,RMN,RSC
 ISN 0012           1 FORMAT(3I5,3F10.0)
 ISN 0013             WRITE(6,2) KMON,KDAY,KYR
 ISN 0014           2 FORMAT(//,5X,'DETECTOR COUNT RATES FOR'I5,1H/,I2,1H/,I2///)
 ISN 0015             TIME=RSC+RMN*60.+RHR*3600.
 ISN 0016             ENTRY EPHM1(TIME,RLON,ALT,RLAT)
 ISN 0017             TDAYP=DAYS(KYR,KMON,KDAY)
 ISN 0018             TDAY=TDAYP+TIME/86400.D0
 ISN 0019             CALL TRACK(TDAY)
 ISN 0020             A=DARSIN(RZ/R)
 ISN 0021             A=A+DSIN(A+A)/(300.D0*R)
 ISN 0022             RLAT=A*RTOD
 ISN 0023             ER=.99832D0+.00168D0*DCOS(A+A)
 ISN 0024             ALT=(R-ER)*AE/1.852
 ISN 0025             RLON=ARIES(TDAY)
 ISN 0026             A=(DATAN2(RY,RX)-RLON)*RTOD
 ISN 0027             RLON=DMOD(A,360.D0)
 ISN 0028             IF(RLON .LT. 0.) RLON=RLON+360.
 ISN 0030             RETURN
 ISN 0031             END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       30 ,PROGRAM SIZE =      1220
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                                DATE  77.021/09.31.53

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002          SUBROUTINE SPCTVO (AZ,EL,XYZ,HS)
  ISN 0003          COMMON/CONST/RADS,DEG,PI,RE
  ISN 0004          DIMENSION XYZ(1)
  ISN 0005          REHS=RE+HS
  ISN 0006          SEL=SIN(EL)
  ISN 0007          CEL=COS(EL)
  ISN 0008          SAZ=SIN(AZ)
  ISN 0009          CAZ=COS(AZ)
  ISN 0010          R=REHS*CEL-SQRT(RE*RE-(REHS*SEL)**2.)
  ISN 0011          XYZ(1)=REHS-R*CEL
  ISN 0012          XYZ(2)=R*SEL*CAZ
  ISN 0013          XYZ(3)=R*SEL*SAZ
  ISN 0014          RETURN
  ISN 0015          END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      14 ,PROGRAM SIZE =      586

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                   557K BYTES OF CORE NOT USED
```

```
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                          553K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                          DATE  77.021/04.32.05

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE START
   ISN 0003            IMPLICIT REAL*8 (A-H,O-Z)
   ISN 0004            REAL*4 KINC,EOM
   ISN 0005            COMMON/ELEM1/IC,XMO,XNO,XNDOT,XNDDOT,ASNO,ASNDOT,ARGO,ARGDOT,
                      1 SINIO,COSIO,AO,EO,XIO
   ISN 0006            COMMON EOM(2),KINC
   ISN 0007            DATA XMU,AJ2,TWOPI,DTOR/11467.67422600,.00108248D0,
                      1 6.283185307180D0,.01745329251990D0/
   ISN 0008            READ(5,100) ISAT,IYR,DAY,XNDOT,XNDDOT
   ISN 0009        100 FORMAT(2X,I5,11X,I2,F12.8,1X,F10.8,1X,E8.5)
   ISN 0010            READ(5,101) XIO,ASNO,EO,ARGO,XMO,XNO
   ISN 0011        101 FORMAT(7X,2(1X,F8.4),F8.7,1X,2(F8.4,1X),F11.8)
   ISN 0012            XIO=XIO*DTOR
   ISN 0013            XMO=XMO*DTOR
   ISN 0014            ASNO=ASNO*DTOR
   ISN 0015            ARGO=ARGO*DTOR
   ISN 0016            SINIO=DSIN(XIO)
   ISN 0017            COSIO=DCOS(XIO)
   ISN 0018            XNO=XNO*TWOPI
   ISN 0019            XNDOT=XNDOT*TWOPI
   ISN 0020            XNDDOT=XNDDOT*TWOPI
   ISN 0021            AO=(XMU/XNO**2)**.33333333333333D0
   ISN 0022            ADEL=-1.5D0*AJ2*(1.D0-1.5D0*SINIO**2)/DSQRT(1.D0-EO**2)**3
   ISN 0023            AO=AO*(1.D0+ADEL*              (1.D0-ADEL/3.D0))
   ISN 0024            IC=DAYS(IYR,1,0)+DAY
   ISN 0025            CON=1.5D0*AJ2*XNO/(AO*(1.D0-EO**2))**2
   ISN 0026            ASNDOT=-CON*COSIO
   ISN 0027            ARGDOT=CON*(2.D0-2.5D0*SINIO**2)
   ISN 0028            KINC =XIO  /DTOR
   ISN 0029            RETURN
   ISN 0030            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      29 ,PROGRAM SIZE =      984
```

```
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                    553K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                          OS/360  FORTRAN H                                    DATE  77.021/09.3?.11

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002          SUBROUTINE TRACK(TIME)
  ISN 0003          IMPLICIT REAL*8 (A-H,O-Z)
  ISN 0004          NAMELIST/CHECK/T,XMM,ASNM,ARGM,XNM,AM,EM,CONL,AXNL,AYNL,ELSQ,EL,
                   * ARGL,XML,E,SINE,COSE
  ISN 0005          COMMON/ORBIT/TO,XMO,XNO,XNDOT,XNDDOT,ASNO,ASNDOT,ARGO,ARGDOT,
                   1 SINIO,COSIO,AO,EO,XIO
  ISN 0006          COMMON/UVW/UX,UY,UZ,VX,VY,VZ,WX,WY,WZ
  ISN 0007          COMMON/RR/RX,RY,RZ,R
  ISN 0008          DATA AJ2,AJ3,TWOPI,RTOD/.0010824800,-2.562D-6,6.2831853071800,
                   1 57.295779513D0/
  ISN 0009          T=TIME-TO
  ISN 0010          XMM=XMO+T*(XNO+T*(XNDOT+T*XNDDOT))
  ISN 0011          ASNM=ASNO+ASNDOT*T
  ISN 0012          ARGM=ARGO+ARGDOT*T
  ISN 0013          XNM=XNO+T*(2.D0*XNDOT+3.D0*T*XNDDOT)
  ISN 0014          AM=AO*(XNO/XNM)**.66666666666670D0
  ISN 0015          EM=1.D0-(1.D0-EO)*AO/AM
  ISN 0016          IF(EM.LE.0.D0)EM=1.D-6
  ISN 0018          CONL=.25D0*(AJ3/AJ2)*SINIO/(AM*(1.D0-EM**2))
  ISN 0019          AXNL=EM*DCOS(ARGM)
  ISN 0020          AYNL=EM*DSIN(ARGM)-2.D0*CONL
  ISN 0021          ELSQ=AXNL**2+AYNL**2
  ISN 0022          EL=DSQRT(ELSQ)
  ISN 0023          ARGL=DATAN2(AYNL,AXNL)
  ISN 0024          XML=XMM+ARGM-ARGL-CONL*AXNL*(3.D0+5.D0*COSIO)/(1.D0+COSIO)
  ISN 0025          XML=DMOD(XML,TWOPI)
  ISN 0026          IF(XML.LT.0.D0)XML=XML+TWOPI
  ISN 0028          E=EXANM(XML,EL)
  ISN 0029          SINE=DSIN(E)
  ISN 0030          COSE=DCOS(E)
  ISN 0031          U=DATAN2(SINE*DSQRT(1.D0-ELSQ),COSE-EL)+ARGL
  ISN 0032          R=AM*(1.D0-EL*COSE)
  ISN 0033          P=AM*(1.D0-ELSQ)
  ISN 0034          CONS=.25D0*AJ2/P**2
  ISN 0035          SIN2U=DSIN(U+U)
  ISN 0036          COS2U=DCOS(U+U)
  ISN 0037          R=R+CONS*SINIO**2*COS2U*P
```

```
ISN 0038      U=U-CONS*SIN2U*(3.D0-3.5D0*SINI0**2)
ISN 0039      XIS=XI0+3.D0*CONS*SINI0*COSI0*COS2U
ISN 0040      ASNS=ASNM+3.D0*CONS*COSI0*SIN2U
ISN 0041      SINASN=DSIN(ASNS)
ISN 0042      COSASN=DCOS(ASNS)
ISN 0043      SINI=DSIN(XIS)
ISN 0044      COSI=DCOS(XIS)
ISN 0045      SINU=DSIN(U)
ISN 0046      COSU=DCOS(U)
ISN 0047      UX=COSU*COSASN-SINU*SINASN*COSI
ISN 0048      UY=COSU*SINASN+SINU*COSASN*COSI
ISN 0049      UZ=SINU*SINI
ISN 0050      VX=-SINU*COSASN-COSU*SINASN*COSI
ISN 0051      VY=-SINU*SINASN+COSU*COSASN*COSI
ISN 0052      VZ=COSU*SINI
ISN 0053      WX=SINASN*SINI
ISN 0054      WY=-COSASN*SINI
ISN 0055      WZ=COSI
ISN 0056      RX=R*UX
ISN 0057      RY=R*UY
ISN 0058      RZ=R*UZ
ISN 0059      RETURN
ISN 0060      END
```

```
                                        FORTRAN H ERROR MESSAGES

                  ERROR NO   LEVEL          ERROR MESSAGE

     NAME    H100   IEK3071      04         THE DATA STATEMENT CONTAINS A VARIABLE THAT IS NOT REFERENCED.

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       59 ,PROGRAM SIZE =      2148

*STATISTICS*    1 DIAGNOSTICS GENERATED, HIGHEST SEVERITY CODE IS  4

****** END OF COMPILATION ******                                        545K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                         OS/360  FORTRAN H                                      DATE  77.021/09.32.20

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            FUNCTION DAYS(IYR,MON,NDAY)
   ISN 0003            DIMENSION MDAY(12)
   ISN 0004            DATA MDAY/0,31,59,90,120,151,181,212,243,273,304,334/
   ISN 0005            NDAYS=365*(IYR-57)+(IYR-57)/4+MDAY(MON)+NDAY
   ISN 0006            LEAP=MOD(IYR,4)
   ISN 0007            IF(LEAP .EQ. 0 .AND. MON .GT. 3) NDAYS=NDAYS+1
   ISN 0009            DAYS=NDAYS
   ISN 0010            RETURN
   ISN 0011            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      10 ,PROGRAM SIZE =      434

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                       557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                    DATE  77.021/09.32.24

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002              FUNCTION EXANM(XM,ECC)
  ISN 0003              IMPLICIT REAL*8 (A-H,O-Z)
  ISN 0004              EXANM=XM
  ISN 0005              DO 10 I=1,50
  ISN 0006              AA=ECC*DSIN(EXANM)
  ISN 0007              DELM=XM-EXANM+AA
  ISN 0008              ZZ=1.D0-ECC*DCOS(EXANM)
  ISN 0009              DELE=DELM/(ZZ+.5D0*DELM*AA/ZZ)
  ISN 0010              IF(DABS(DELE) .GT. 1.) DELE=DELE/DABS(DELE)
  ISN 0012              EXANM=EXANM+DELE
  ISN 0013              IF(DABS(DELE) .LT. 1.D-6) RETURN
  ISN 0015           10 CONTINUE
  ISN 0016              WRITE(6,11)
  ISN 0017           11 FORMAT(10X,27HITERATION DOES NOT CONVERGE )
  ISN 0018              RETURN
  ISN 0019              END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       16 ,PROGRAM SIZE =       568

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                              557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                        OS/360  FORTRAN H                                   DATE  77.021/09.32.29

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002          FUNCTION ARIES(DAYS)
  ISN 0003          IMPLICIT REAL*8 (A-H,O-Z)
  ISN 0004          DATA TWOPI/6.283185307180D0/
  ISN 0005          T=(DAYS+20816.5D0)/36525.D0
  ISN 0006          ARIES=(23925.836D0+T*(8640184.542D0+.0929D0*T))/86400.D0
                   1  +DMOD(DAYS,1.D0)
  ISN 0007          ARIES=DMOD(ARIES,1.D0) *TWOPI
  ISN 0008          RETURN
  ISN 0009          END

*OPTIONS IN EFFECT*     NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       6 ,PROGRAM SIZE =       386

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                      557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                     OS/360  FORTRAN H                          DATE  77.021/09.32.33

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002          FUNCTION ACOS(X)
  ISN 0003          ACOS=ARCOS(X)
  ISN 0004          RETURN
  ISN 0005          END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =        4 ,PROGRAM SIZE =       226

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                    557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                         OS/360  FORTRAN H                                   DATE  77.021/09.32.37

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002          FUNCTION ASIN(X)
  ISN 0003          ASIN=ARSIN(X)
  ISN 0004          RETURN
  ISN 0005          END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =       4 ,PROGRAM SIZE =      226

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                        557K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 75 )                    OS/360  FORTRAN H                              DATE  77.021/09.32.41

           COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                              SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
   ISN 0002            SUBROUTINE MINV(A,N,D,L,M)
                 C
                 C        ..............................................................
                 C
                 C           FUNCTION RECP
                 C
                 C           PURPOSE
                 C              CALCULATE RECIPROCAL OF AN ELEMENT. THIS IS A FORTRAN
                 C              FUNCTION SUBPROGRAM WHICH MAY BE USED AS AN ARGUMENT BY
                 C              SUBROUTINE MFUN.
                 C
                 C           USAGE
                 C              RECP(E)
                 C
                 C           DESCRIPTION OF PARAMETERS
                 C              E - MATRIX ELEMENT
                 C
                 C           REMARKS
                 C              RECIPROCAL OF ZERO IS TAKEN TO BE 1.0E75
                 C
                 C           SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
                 C              NONE
                 C
                 C           METHOD
                 C              RECIPROCAL OF ELEMENT E IS PLACED IN RECP
                 C
                 C        ..............................................................
                 C
                 C
                 C
                 C           TEST ELEMENT FOR ZERO
                 C
                 C
                 C           IF NON-ZERO, CALCULATE RECIPROCAL
                 C
                 C
                 C           IF ZERO, SET EQUAL TO INFINITY
```

```
            C
            C
            C      ...............................................................
            C
            C         SUBROUTINE MINV
            C
            C         PURPOSE
            C            INVERT A MATRIX
            C
            C         USAGE
            C            CALL MINV(A,N,D,L,M)
            C
            C         DESCRIPTION OF PARAMETERS
            C            A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY
            C                RESULTANT INVERSE.
            C            N - ORDER OF MATRIX A
            C            D - RESULTANT DETERMINANT
            C            L - WORK VECTOR OF LENGTH N
            C            M - WORK VECTOR OF LENGTH N
            C
            C         REMARKS
            C            MATRIX A MUST BE A GENERAL MATRIX
            C
            C         SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
            C            NONE
            C
            C         METHOD
            C            THE STANDARD GAUSS-JORDAN METHOD IS USED. THE DETERMINANT
            C            IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT
            C            THE MATRIX IS SINGULAR.
            C
            C      ...............................................................
            C
ISN 0003           DIMENSION A(1),L(1),M(1)
            C
            C         ............................................................
            C
            C         IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE
            C         C IN COLUMN 1 SHOULD BE REMOVED FROM THE DOUBLE PRECISION
```

```
              C        STATEMENT WHICH FOLLOWS.
              C
              C     DOUBLE PRECISION A,D,BIGA,HOLD
              C
              C        THE C MUST ALSO BE REMOVED FROM DOUBLE PRECISION STATEMENTS
              C        APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS
              C        ROUTINE.
              C
              C        THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO
              C        CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS.  ABS IN STATEMENT
              C        10 MUST BE CHANGED TO DABS.
              C
              C        ...........................................................
              C
              C        SEARCH FOR LARGEST ELEMENT
              C
ISN 0004            D=1.0
ISN 0005            NK=-N
ISN 0006            DO 80 K=1,N
ISN 0007            NK=NK+N
ISN 0008            L(K)=K
ISN 0009            M(K)=K
ISN 0010            KK=NK+K
ISN 0011            BIGA=A(KK)
ISN 0012            DO 20 J=K,N
ISN 0013            IZ=N*(J-1)
ISN 0014            DO 20 I=K,N
ISN 0015            IJ=IZ+I
ISN 0016         10 IF( ABS(BIGA)- ABS(A(IJ))) 15,20,20
ISN 0017         15 BIGA=A(IJ)
ISN 0018            L(K)=I
ISN 0019            M(K)=J
ISN 0020         20 CONTINUE
              C
              C        INTERCHANGE ROWS
              C
ISN 0021            J=L(K)
ISN 0022            IF(J-K) 35,35,25
ISN 0023         25 KI=K-N
```

```
ISN 0024          DO 30 I=1,N
ISN 0025          KI=KI+N
ISN 0026          HOLD=-A(KI)
ISN 0027          JI=KI-K+J
ISN 0028          A(KI)=A(JI)
ISN 0029       30 A(JI) =HOLD
              C
              C        INTERCHANGE COLUMNS
              C
ISN 0030       35 I=M(K)
ISN 0031          IF(I-K) 45,45,38
ISN 0032       38 JP=N*(I-1)
ISN 0033          DO 40 J=1,N
ISN 0034          JK=NK+J
ISN 0035          JI=JP+J
ISN 0036          HOLD=-A(JK)
ISN 0037          A(JK)=A(JI)
ISN 0038       40 A(JI) =HOLD
              C
              C        DIVIDE COLUMN BY MINUS PIVOT (VALUE OF PIVOT ELEMENT IS
              C        CONTAINED IN BIGA)
              C
ISN 0039       45 IF(BIGA) 48,46,48
ISN 0040       46 D=0.0
ISN 0041          RETURN
ISN 0042       48 DO 55 I=1,N
ISN 0043          IF(I-K) 50,55,50
ISN 0044       50 IK=NK+I
ISN 0045          A(IK)=A(IK)/(-BIGA)
ISN 0046       55 CONTINUE
              C
              C        REDUCE MATRIX
              C
ISN 0047          DO 65 I=1,N
ISN 0048          IK=NK+I
ISN 0049          HOLD=A(IK)
ISN 0050          IJ=I-N
ISN 0051          DO 65 J=1,N
ISN 0052          IJ=IJ+N
```

```
ISN 0053            IF(I-K) 60,65,60
ISN 0054         60 IF(J-K) 62,65,62
ISN 0055         62 KJ=IJ-I+K
ISN 0056            A(IJ)=HOLD*A(KJ)+A(IJ)
ISN 0057         65 CONTINUE
          C
          C         DIVIDE ROW BY PIVOT
          C
ISN 0058            KJ=K-N
ISN 0059            DO 75 J=1,N
ISN 0060            KJ=KJ+N
ISN 0061            IF(J-K) 70,75,70
ISN 0062         70 A(KJ)=A(KJ)/BIGA
ISN 0063         75 CONTINUE
          C
          C         PRODUCT OF PIVOTS
          C
ISN 0064            D=D*BIGA
          C
          C         REPLACE PIVOT BY RECIPROCAL
          C
ISN 0065            A(KK)=1.0/BIGA
ISN 0066         80 CONTINUE
          C
          C         FINAL ROW AND COLUMN INTERCHANGE
          C
ISN 0067            K=N
ISN 0068        100 K=(K-1)
ISN 0069            IF(K) 150,150,105
ISN 0070        105 I=L(K)
ISN 0071            IF(I-K) 120,120,108
ISN 0072        108 JQ=N*(K-1)
ISN 0073            JR=N*(I-1)
ISN 0074            DO 110 J=1,N
ISN 0075            JK=JQ+J
ISN 0076            HOLD=A(JK)
ISN 0077            JI=JR+J
ISN 0078            A(JK)=-A(JI)
ISN 0079        110 A(JI) =HOLD
```

```
ISN 0080        120 J=M(K)
ISN 0081            IF(J-K) 100,100,125
ISN 0082        125 K1=K-N
ISN 0083            DO 130 I=1,N
ISN 0084            K1=K1+N
ISN 0085            HOLD=A(K1)
ISN 0086            J1=K1-K+J
ISN 0087            A(K1)=-A(J1)
ISN 0088        130 A(J1) =HOLD
ISN 0089            GO TO 100
ISN 0090        150 RETURN
ISN 0091            END

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      90 ,PROGRAM SIZE =     1572

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  541K BYTES OF CORE NOT USED
```

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002               SUBROUTINE GRID
ISN 0003               COMMON/CONST/RADS
ISN 0004               COMMON/VEC/U(3,20),V(3,20),W(3,20),ALT(20),ALPHA(20)
ISN 0005               COMMON/GUESS/GUESSO(3)
ISN 0006               COMMON SATUNE(5),NE,AZ(10),EL(10),NT,TIMES(20),SM(200),TARLOC(3)
ISN 0007               DIMENSION S(200),XX(11),YY(11),RES(11,11)
                 C GENERATE LATITUDE AND LONGITUDE GRID WHICH SPANS +- 5 DEG OF INITIAL
                 C TARGET GUESS
ISN 0008               NS=NT*NE
ISN 0009               LATE=MAX1(GUESSO(1)-5.,0.)
ISN 0010               LONE=MAX1(GUESSO(2)-5.,0.)
ISN 0011               LONE=LONE+10.
ISN 0012               TARLOC(3)=GUESSO(3)
                 C FIND SUM OF MEASURED RATES TO USE IN SCALE FACTOR
ISN 0013               S1=0.
ISN 0014               DO 15 I=1,NS
ISN 0015            15 S1=S1+SM(I)
ISN 0016               DO 100 I=1,11
ISN 0017               XX(I)=I-1+LATE
ISN 0018               TARLOC(1)=XX(I)*RADS
ISN 0019               DO 75 J=1,11
ISN 0020               YY(J)=J-1+LONE
ISN 0021               TARLOC(2)=YY(J)*RADS
ISN 0022               CALL OUTPUT(S)
ISN 0023               S2=0.
ISN 0024               DO 40 K=1,NS
ISN 0025            40 S2=S2+S(K)
ISN 0026               SF=S1/S2
ISN 0027               SUM=0.
ISN 0028               DO 50 K=1,NS
ISN 0029            50 SUM=SUM+(SM(K)-SF*S(K))**2
ISN 0030               RES(I,J)=SQRT(SUM)
ISN 0031            75 CONTINUE
ISN 0032           100 CONTINUE
ISN 0033               CALL CONTOR (XX,YY,RES,11,11,11)
ISN 0034               RETURN
ISN 0035               END
```

```
*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
*STATISTICS*     SOURCE STATEMENTS =       34 ,PROGRAM SIZE =     2324
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                                549K BYTES OF CORE NOT USED
```

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=41,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
ISN 0002            SUBROUTINE CONTUR (X,Y,Z,NX,NY,NDIMZ)
ISN 0003            DIMENSION X(2),Y(2),Z(NDIMZ,2)
ISN 0004            DIMENSION LINE(101),ISYM(37),CONV(37),XLABEL(11)
ISN 0005            DATA ISYM/37*1H /
ISN 0006            DATA ISYM(1),ISYM(5),ISYM(9),ISYM(13),ISYM(17),ISYM(21),ISYM(25),
                   * ISYM(29),ISYM(33),ISYM(37)/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,
                   * 1H9/
ISN 0007            NCON=33
ISN 0008            ZMAX=Z(1,1)
ISN 0009            ZMIN=Z(1,1)
ISN 0010            DO 100 IX=1,NX
ISN 0011            DO 100 IY=1,NY
ISN 0012            ZZ=Z(IX,IY)
ISN 0013            IF(ZZ.GT.ZMAX)ZMAX=ZZ
ISN 0015            IF(ZZ.LT.ZMIN)ZMIN=ZZ
ISN 0017        100 CONTINUE
ISN 0018            IF(ZMAX.EQ.ZMIN)RETURN
ISN 0020            XMIN=X(1)
ISN 0021            XMAX=X(NX)
ISN 0022            YMIN=Y(1)
ISN 0023            YMAX=Y(NY)
ISN 0024            DX=(XMAX-XMIN)/100.0
ISN 0025            DY=(YMAX-YMIN)/40.0
ISN 0026            DELC=(ZMAX-ZMIN)/FLOAT(NCON-1)
ISN 0027            CONV(1)=ZMIN
ISN 0028            DO 110 I=2,NCON
ISN 0029        110 CONV(I)=CONV(I-1)+DELC
ISN 0030            WRITE(6,90)
ISN 0031         90 FORMAT(1H1,T119,12HSYMBOL TABLE,/15X,10('+----------'),'+')
ISN 0032            II=1
ISN 0033            YY=YMAX+DY
ISN 0034            DO 540 LY=1,41
ISN 0035            YY=YY-DY
ISN 0036            XX=XMIN-DX
ISN 0037            DO 500 LX=1,101
ISN 0038            XX=XX+DX
ISN 0039            IA=1
```

```
ISN 0040          IN=NX
ISN 0041      300 IL=IN
ISN 0042      310 IF((IL-IA).LE.1)GO TO 320
ISN 0044          IN=(IA+IL)/2
ISN 0045          IF(X(IN).GE.XX)GO TO 300
ISN 0047          IA=IN
ISN 0048          GO TO 310
ISN 0049      320 IPX=IA
ISN 0050          IA=1
ISN 0051          IN=NY
ISN 0052      400 IL=IN
ISN 0053      410 IF((IL-IA).LE.1)GO TO 420
ISN 0055          IM=(IA+IL)/2
ISN 0056          IF(Y(IM).GE.YY)GO TO 400
ISN 0058          IA=IM
ISN 0059          GO TO 410
ISN 0060      420 IPY=IA
ISN 0061          FRX=(XX-X(IPX))/(X(IPX+1)-X(IPX))
ISN 0062          FRY=(YY-Y(IPY))/(Y(IPY+1)-Y(IPY))
ISN 0063          ZU=Z(IPX,IPY+1)+FRX*(Z(IPX+1,IPY+1)-Z(IPX,IPY+1))
ISN 0064          ZL=Z(IPX,IPY)+FRX*(Z(IPX+1,IPY)-Z(IPX,IPY))
ISN 0065          ZZ=ZL+FRY*(ZU-ZL)
ISN 0066          IZ=(ZZ-ZMIN)/DELC+1.5
ISN 0067          IZ=MINO(NCON,MAXO(1,IZ))
ISN 0068      500 LINE(LX)=ISYM(IZ)
ISN 0069          IF(MOD(LY-1,4) .NE. 0) GO TO 518
ISN 0071          IF(II .LE. NCON) GO TO 511
ISN 0073          WRITE(6,510)YY,LINE
ISN 0074      510 FORMAT(1PE13.2,' +',101A1,'+')
ISN 0075          GO TO 540
ISN 0076      511 WRITE(6,512)YY,LINE,ISYM(II),CONV(II)
ISN 0077      512 FORMAT(1PE13.2,' +',101A1,'+',1X,A1,2X,E11.4)
ISN 0078          II=II+4
ISN 0079          GO TO 540
ISN 0080      518 IF(II .GT. NCON) GO TO 520
ISN 0082          WRITE(6,519)LINE,ISYM(II),CONV(II)
ISN 0083      519 FORMAT(14X,'I',101A1,'I',1X,A1,2X,1PE11.4)
ISN 0084          II=II+4
ISN 0085          GO TO 540
```

```
ISN 0086       520 WRITE(6,530)LINE
ISN 0087       530 FORMAT(14X,'I',101A1,'I')
ISN 0088       540 CONTINUE
ISN 0089           XLABL(1)=XMIN
ISN 0090           DX=(XMAX-XMIN)/10.0
ISN 0091           DO 550 I=2,11
ISN 0092       550 XLABL(I)=XLABL(I-1)+DX
ISN 0093           WRITE(6,560)XLABL
ISN 0094       560 FORMAT(15X,10('+---------'),'+'/10X,11(1PE10.2))
ISN 0095           WRITE(6,220)X(6),Y(6)
ISN 0096       220 FORMAT(/17X,'ISORESIDUAL CONTOURS CENTERED ON TARGET GUESS (LAT,LO
                  *N) OF',2F10.2,' DEGREES')
ISN 0097           RETURN
ISN 0098           ENTRY PRPLOT
ISN 0099           RETURN
ISN 0100           ENTRY STPLOT
ISN 0101           RETURN
ISN 0102           ENTRY ARLTAT
ISN 0103           RETURN
ISN 0104           ENTRY ERPLOT
ISN 0105           RETURN
ISN 0106           END

*OPTIONS IN EFFECT*     NAME=  MAIN,LPT=02,LINECNT=41,SIZE=0000K,

*OPTIONS IN EFFECT*     SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*    SOURCE STATEMENTS =     105 ,PROGRAM SIZE =     3220

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  541K BYTES OF CORE NOT USED

*STATISTICS*    2 DIAGNOSTICS THIS STEP, HIGHEST SEVERITY CODE IS  4
```

F64-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED MAP,LIST
DEFAULT OPTION(S) USED - SIZE=(126976,24576)

MODULE MAP

CONTROL SECTION

NAME	ORIGIN	LENGTH
MAIN	00	14C
ALLEPH	150	20C
DATIN	360	8AC
DETOUT	C0E	40C
DOT	1020	11C
OUTPUT	11F0	242
REFINE	1438	140A
RESPON	290E	E2
ROTS	29F0	2F2
SPLTVD	2CE8	24A
EPHM	2EF8	404
START	3300	3D8
TRACK	3798	664
DAYS	4000	1E2
EXANM	41E8	238
ARIES	43F0	182
ACOS	4578	E2
ASIN	4660	E2
MINV	4748	624
GRID	4D70	914
CONTOR	5688	C94
IHCSATN2*	6320	1CE
IHCSSCN *	64F0	1D9
IHCLATN2*	6600	2?1
IHCLSCN *	6928	26C
IHCFRXPR*	6E98	183
IHCECOMH*	6D20	F61

ENTRY

NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
EPHM1	3324						
PRPLOT	620C	STPLOT	6250	ANOTAT	6294	ENPLOT	62D8
ATAN2	6320	ATAN	6334				
COS	64F0	SIN	6508				
DATAN2	6600	DATAN	6616				
DCOS	6928	DSIN	6942				
FRXPR=	6E98						
IBCOM=	6D20	FDIOCS=	6DDC	INTSWTCH	7C66		

```
INCCOMM2*   7C9E   61E        SECDASD   E000
INCSSWRT*   82EB   145        SQRT      82E8
INCFCVTH*   8430   119C       ADCON=    E430   FCVADUTP   E4DA   FCVLCUTP   65EA   FCV2OUTP   66EA
                              FCVIOUTP  EA6A   FCVEOUTP   EFFA   FCVCOUTP   91F4   INT6SWCH   94EE
INCSLOG *   95D0   1E6        ALOG10    95D0   ALOG       95E6
```

NAME	ORIGIN	LENGTH
IHCSASCN*	47B8	11F
IHCLASCN*	9968	24F
IHCLSCRT*	9BB8	15C
IHCSEXP *	9D18	142
IHCFDXPD*	9E60	1A0
IHCEFIOS*	A050	F28
IHCFIOS2*	AF78	52C
IHCERRM *	B4A8	5B4
IHCEFNTH*	BA60	542
IHCLEXP *	BFC8	28B
IHCLLOG *	C250	200
IHCLTRCH*	C450	28C
IHCUATBL*	C6E0	638
IHCECPT *	CD18	300
$BLANKCOM	D018	3EC
CONST	D408	10
VEC	D418	370
DAY	D788	4
GUESS	D790	C
ITER	D7A0	4
OVW	D7A8	48
SATPOS	D7F0	A0
FR	D890	20
GRETI	D8B0	70

NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
ARCOS	47B8	ARSIN	479E				
DARCOS	9968	DARSIN	9980				
DSQRT	9BB8						
EXP	9D18						
FDXPD=	9E60						
FIOCS=	A050	FIOCSBEP	A056				
ERRMON	B4A8	IHCSFRE	B4C0				
ARITH=	BA60	ADJSWTCH	BE1C				
DEXP	BFC8						
DLOG10	C250	DLOG	C268				
IHCTRCH	C450	ERRTRA	C458				

ENTRY ADDRESS 60

TOTAL LENGTH D950

****MAIN DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET

AUTHORIZATION CODE IS 0.

THE IVAN A. GETTING LABORATORIES

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